OBSERVATIONS

ON THE

CIRCULATION

OF THE

BLOOD,

AND ON THE

EFFECTS OF BLEEDING.

By JOHN HUNT,

A MEMBER OF THE CORPORATION OF SURGEONS.

LONDON:

PRINTED FOR J. JOHNSON, NO. 72, ST. PAUL'S CHURCH-YARD; AND C. ELLIOT, EDINBURGH.

MDCC LXXXVII.

[PRICE TWO SHILLINGS.]

PREFACE.

MOST Readers will allow, that Anatomy and Phyſiology may juſtly be conſidered as the true baſis of Medical Knowledge; and perhaps no part of them is more intimately connected with the practice of Phyſic, than that which is the ſubject of the following pages. I hope therefore that the importance of the object of theſe enquiries will in ſome degree juſtify their publication, and that the number of books that have been already written nearly on the ſame ſubject will not be conſidered

as a ſufficient objection to any further enquiry, ſo long as the preſent theory of the action of the arteries remains in a ſtate of ſuch uncertainty and imperfection.

The following arguments would perhaps have met with more general approbation, if I had endeavoured to ſupport the different opinions that I have advanced by what are commonly called matters of fact, ſuch as were either deduced from experiments, or collected from caſes where one certain method of treatment has appeared more efficacious than another. With reſpect to experiments, I think they are ſufficiently numerous already, and that more have been made than well explained. But if the authority of experiments is thought neceſſary, thoſe that have been made with the greateſt accuracy, and faithfully recorded by Haller, Dr. Hales, and a few others, are ſufficient to prove to a demonſtration every one of the following obſervations; and as for a hiſtory of ſucceſsful

or unſucceſsful caſes, I muſt agree with Mr. Pott *, that they cannot be much depended on: but as the following arguments are more particularly addreſſed to the Faculty, and not calculated for the general claſs of Readers, every one that is ſo inclined may try their validity by his own practical obſervations. However, it will be neceſſary to conſider, that though by one certain method of treatment the patient received evident relief, and even recovered from his diſeaſe, this is no poſitive proof that if ſome other method had been uſed, and that omitted, that the treatment would not have been

* Mr. Pott (in the Preface to his Obſervations on Wounds on the Head) ſays, "I could produce many hiſtories to confirm my aſſertions, if I thought that they would add to their uſe or force, but have ſuppreſſed them, becauſe they do not appear to me likely to do either; as the reader muſt ſtill depend upon my veracity, as much in one inſtance as in the other: the man who is capable of aſſerting what he knows to be falſe, muſt have a very defective imagination not to be able to form caſes in its ſupport."

been more efficacous. For inſtance, ſuppoſe in caſe of apoplexy, a pound of blood was taken from the temporal artery, and the patient recovers, it will be impoſſible to determine that this method was preferable to every other, or even that if the patient had been bled in the arm, the advantage would not have been more conſiderable, and the recovery more complete: or ſuppoſe in a ſimilar inſtance, the temporal artery was opened, and the patient died, we cannot from the want of ſucceſs determine what might have been the conſequence, if a vein had been opened inſtead of an artery.—So that it is not poſſible that the advocates for the different opinions ſhould ever with any degree of certainty decide the point in queſtion from † the evidence of a few caſes; for though facts are generally conſidered as inconteſtible arguments, at the ſame time it will be neceſſary to remember, that by a miſ-

application

† Sharp's Critical Enquiry, p. 255.

application of facts, it is very poſſible to give the appearance of plauſibility to the moſt palpable abſurdities; and an improper choice of facts will be productive of as great uncertainty. The facts themſelves ſhould firſt be well conſidered, and every compound fact ſhould be critically analyzed, before it is admitted as the foundation of any theoretical argument.—The ſimple operations of the animal œconomy are the only facts that can be depended upon in this inſtance; and even theſe ſimple facts will prove of little ſervice without a rational theory to connect them. Facts without doubt are the foundation of theory, but it is theory which teaches how to connect ſimple facts in the proper order in which they naturally ſucceed each other; it is theory which teaches how to trace evident facts to their remote, if not to their firſt cauſes—and alſo how to diſtinguiſh cauſes from effects, and effects from cauſes:—The object of theory is therefore the acquiring a clear, diſtinct, and accu-

rate

rate knowledge of the firſt principles and laws of nature; and thus without theory, the accumulation of facts muſt undoubtedly prove an unintelligible chaos. At the ſame time it will be neceſſary to obſerve, that that theory which is the production of a fertile imagination, and only founded on book-knowledge, without a proper foundation of well known facts, when formed with a certain degree of plauſibility, muſt undoubtedly prove, before all others, the greateſt impediment to every ſpecies of philoſophical inveſtigation.

The method that I have purſued in the following pages appeared to me beſt adapted to my preſent purpoſe, and the limits of the ſubject have been determined by the nature of the objects of enquiry. I have ſtudiouſly endeavoured to copy Nature, without being influenced by the opinions of others; and if the matter is thought worthy the attention of the Reader, I hope the manner,

ner, if intelligible, will be excuſed with all the imperfections: for though purity of language and elegance of ſtyle are ornaments that ſhould never be neglected, they do not appear ſo abſolutely neceſſary on this occaſion, as it is not the conſtruction of words and ſentences that is the object of theſe enquiries, but the anatomy of the arterial ſyſtem, and thoſe laws of the animal œconomy, which regulate and influence the motion of the blood.

CONTENTS.

OBSERVATIONS

ON THE

CIRCULATION OF THE BLOOD, &c.

SECTION I.

Of the preſent State of this Part of Phyſiology.

THE courſe of the blood through the heart and lungs, and through the arterial and venal ſyſtems, was firſt demonſtrated by the great HARVEY; but the different animal functions that promote the circulation of the blood, have been explained by ſlow degrees. The principles on which the ſyſtole and diaſtole of the heart depend, was a ſubject that engaged the attention of the firſt phyſiologiſts, but was

little underſtood, until Haller publiſhed his Experiments on Irritability, which were afterwards farther illuſtrated by Whytt's Eſſays on the Vital and other involuntary Motions of Animals; and even at the preſent period, as our knowledge of the conſtruction, powers and properties of various parts of the animal body, remains very imperfect; ſo in particular, the action of the arteries and the motion of the blood through their cavities, have never yet been perfectly explained, or generally underſtood.

In the following diſquiſitions on this ſubject, I ſhall carefully avoid the admiſſion of ſuch doubtful experiments as may give various appearances for want of ſufficient accuracy in the operation, or may at leaſt admit of different concluſions; and ſhall only attend to a few evident facts, that are well known to every anatomiſt, and may be repeatedly obſerved without the leaſt hazard of want of uniformity in the moſt important circumſtances: by which means many difficulties will be avoided, which, in ſimilar inſtances, inſtead of explaining the principles

ciples of nature, have proved the foundation of innumerable errors; and the ſubject that was intended to have been thereby illuſtrated, has been left in greater obſcurity. Equal difficulties would undoubtedly attend every attempt to explain that property of the arteries which is the cauſe of their muſcular action, by the moſt accurate repetition of ſuch experiments that have been made on living, or more ſtrictly ſpeaking, on dying animals, on the ſubject of irritability, and for this evident reaſon; becauſe, in all enquiries into the laws of the animal œconomy, it is neceſſary that the ſeveral parts ſhould be in a perfect † ſtate, and actuated by the powers of nature only, which is not conſiſtent with the nature of thoſe experiments that have been uſed to determine the exiſtence and degree of irritability or ſenſibility of different parts; and for want of attention to this particular, every experiment will be attended with ambiguity, and the moſt refined and plauſible arguments will prove exceptionable, and ſubject to the following objections.

† Whytt on Senſibility, p. 261.

The pain that the animal would ſuffer by the diſſection to expoſe an artery, might conſiderably diminiſh, or totally deſtroy, the natural irritability of the part; or the diviſion of the veſſel might do ſo much injury to the muſcular coat, that the power of action might be deſtroyed, and the veſſel not contract, though it was effectually irritated; or cutting the veſſel to get at the internal ſurface, might prove a ſtronger ſtimulus than what would be afterwards applied; and as it would be difficult to evacuate all the blood, which is the proper ſtimulus provided by nature, and impoſſible to prevent the admiſſion and contact of the air, which might prove a ſtimulus; conſequently the veſſel could not be obſerved but in a ſtate of irritation.

But when our enquiries are directed to ſubjects of much leſs difficult inveſtigation, we are frequently deceived by attending to the deluſive appearances of anatomical experiments; if we do not at the ſame time attentively conſider the true principles upon which theſe appearances depend. For inſtance, the appearances that take place when the carotid arteries are divided,

are

are ſo very different to what is obſervable when a ſmall artery is divided, or when one of theſe veſſels is only ſlightly wounded, that this ſingle circumſtance has given riſe to an hypotheſis §, which, contrary to the general opinion, ſuppoſes that there is neither ſyſtole or diaſtole in the arteries, and that the blood moves through their cavities with a regular and unremitting velocity. But the natural courſe of the circulation is ſo changed when the carotid arteries are divided, that this experiment cannot poſſibly lead to any ſuch concluſion, but, on the contrary, this furniſhes us with an inſtance that evidently proves the effects of diminiſhed reſiſtance in any part of the arterial ſyſtem. That I might be perfectly ſatisfied of the certainty of the fact, I repeated the experiment, and found that when the carotid arteries of a ſheep were ſuddenly divided, the blood was diſcharged from their cavities with a continued ſtream, and with uniform velocity, and that there was not the leaſt motion to be perceived in the divided veſſels, until the greateſt part of the blood was evacuated. What at firſt

§ Dr. Kirkland's Medical Surgery, Vol. I. p. 307.

view appears moſt ſingular in this experiment is, that though the blood is propelled from the heart at intervals, the diſcharge from the carotid arteries ſhould be conſtant and regular—and it is alſo neceſſary to obſerve, that the quantity of blood that is diſcharged in a given time far exceeds the quantity that paſſes the heart; for if the dimenſions of the left ventricle of the heart, and the number of pulſations be nearly aſcertained, the quantity of blood that enters the aorta from the heart in the ſame time, may be eſtimated with ſufficient accuracy by a mental calculation, to give the moſt evident proof of the truth of this aſſertion; conſequently the blood muſt come ſome other way, to paſs through the divided veſſels. And as the ſemilunar valves placed at the origin of the aorta are the only valves in the whole arterial ſyſtem, there is no impediment to prevent the return of the blood from the extreme ramifications of the arteries, towards the divided carotids, where all reſiſtance is deſtroyed; and thus the blood being preſſed by the natural contraction of the arteries, and by the convulſive action of the circumjacent muſcles, will return from all the extreme

treme parts of the arteries, and the whole contents of the arteries returning at the ſame time by the aorta deſcendens and the two ſubclavians, together with what comes through the aorta aſcendens from the heart, will occaſion a ſupply in the curvature of the aorta, that will exceed the diſcharge at the divided carotids; conſequently the ſuperior part of the aorta will be diſtended by the preſſure of the accumulated blood *; and the re-action continuing the ſame without intermiſſion, will force the blood through the carotid arteries with a regular and uniform velocity. But it is impoſſible that this effect ſhould be produced by the power of the heart alone: if it was not for theſe co-operating powers, that continue to act during the diaſtole of the ventricle. For the diſtance from the left ventricle of the heart, through the cur-

* Haller's Diſſertation on the Motion of the Blood, p. 102. When either the heart or the aorta is cut off, generally the blood of the meſenteric arteries moves retrograde. Ibid, p. 143. The blood of an animal whoſe heart is deſtroyed, doth not move only from great veſſels to ſmall ones, but it more frequently moves from the ſmall branches to the great ones. See alſo p. 139.

vature of the aorta to the open orifices of the divided carotid arteries is ſo ſhort, and as the blood will meet with no reſiſtance † when the continuity of theſe veſſels is deſtroyed, theſe veſſels would be very little diſtended, and the blood would be diſcharged at intervals, correſponding to the motions of the heart, which is evidently proved by what takes place before the concluſion of this experiment; for as the whole arterial ſyſtem is perfectly evacuated ſome little time before the death of the animal, and as the heart ſtill continues to tranſmit the blood from the cava to the aorta, the blood is then diſcharged from the divided carotids at intervals, correſponding to the ſyſtole of the left ventricle; and the veins at that time being alſo nearly evacuated, the quantity of blood that ſupplies the heart will be diminiſhed at every pulſation, and conſequently the action of the heart, and the quantity of blood diſcharged by the carotids at each impulſe, will gradually diminiſh, until the animal expires. From this and ſimilar inſtances, it is reaſonable to conclude, that the operations of nature,

† Critical Review, April 1783, p. 256.

nature, in the moſt ſimple and perfect ſtate, will prove the ſafeſt guide to truth; and thoſe parts are moſt proper for obſervation that are evident to the ſenſes, without the aſſiſtance of optical inſtruments: for if the laws of the animal œconomy cannot be inveſtigated by attending to the operations of thoſe parts that are evident to the ſight, and are capable of being examined by the fingers and diſſection, it is not probable that the reſult of our enquiries will prove more ſucceſsful when we attempt to inveſtigate thoſe parts that are in themſelves too minute to be ſeen without the aſſiſtance of the microſcope, and but imperfectly with it. In my opinion, the microſcope has never much enlightened this ſubject; but on the contrary, it has given ſome authors a fine opportunity of deſcribing whatever their imaginations painted, and what no eyes but their own have ever ſince been able to diſcover: for inſtance, the refined and ſpeculative theories on the doctrine of blood globules are not demonſtrable at the preſent day; and we have every reaſon to believe, that, even with the ſame inſtruments, it would be impoſſible to repeat the ſame experiments with the boaſted ſucceſs.—

Dr.

Dr. Whytt || has attempted to demonſtrate with mathematical accuracy, that the powers of the microſcope are not ſufficient to ſhew the motion of the ſmall capillary arteries, where the blood is ſuppoſed to paſs by ſingle globules; and it appears very doubtful whether either Lewenhoek or Hewſon ever ſaw any ſuch thing as a blood globule, if in reality there is any ſuch exiſtence in nature. Then as it is moſt probable that the minutiæ of anatomy (which is at preſent very imperfectly known) will be beſt diſcovered, by obſerving the analogy between the large parts and the ſmall ones;—it is very ſingular, that ſo many ingenious anatomiſts, who have attempted to explain the nature of the circulation of the blood, ſhould have deduced their arguments from the uncertain evidence of microſcopic obſervation.

|| Whytt's Works, p. 236.

SECT.

SECT. II.

Of the Uſe and Abuſe of Mechanical Illuſtrations.

THE ſtudy of mechanics has, in ſome degree, always been united with ſurgery; and the deſire that has univerſally prevailed to become the author of ſome improvement in this part of medical knowledge, has introduced a number of ſtrange uncouth inſtruments into every department of medicine where manual aſſiſtance is required; but the unfitneſs of ſome of theſe inſtruments for their intended purpoſes plainly ſhews the great deficiency of either the mechanical or anatomical knowledge that was neceſſary to have formed ſuch inſtruments complete and uſeful. Indeed the operative part of ſurgery is in a great meaſure mechanical, and to be well acquainted with the diſtribution of the different parts concerned in operations, may be ſufficient for ſuch purpoſes; but a deſcriptive knowledge

knowledge of anatomy is but one part neceſſary towards inveſtigating the laws of the animal œconomy. I ſhall not take upon me to deny, but that when certain ſimilies are well adapted, and properly introduced, they may in ſome degree facilitate deſcription, and promote the attainment of phyſical knowledge; but they more frequently tend to lead the mind into error, than to improve our ideas.—For inſtance, the late Dr. Hunter was much admired for his happy ſimilies*; but how he failed, when he compared the aneuriſmal eſchar to the ſucker of a pump, is too evident to eſcape obſervation; and ſome anatomiſts have gone much farther, and attempted to explain the circulation of the blood on the principles of hydraulic machines, and with this intention have compared the vaſcular ſyſtem to the different parts of a fire engine (*i. e.* an engine to extinguiſh fire); but the inconſiſtency of ſuch a repreſentation muſt appear perfectly evident to every one who has the leaſt knowledge of the anatomy of the one, and the mechaniſm of the other. But as ſuch ſimilies have been uſed by different authors, and not with

* Medical Obſervations and Inquiries, Vol. I. p. 330.

with the moſt ſtrict propriety, it becomes neceſſary that we examine how far they may aſſiſt our inquiries, or prove diſadvantageous; and as the diaſtole of the arteries is chiefly mechanical, we ſhall find that on ſuch principles only (as the arteries are capable of diſtention and contraction) it is impoſſible they ſhould remain without motion. Dr. Mihles, in his tranſlation of Haller's Outlines of Phyſiology, has added an illuſtration of this kind, that has attracted the attention of ſome anatomiſts †, and they have quoted the obſervation with the original intention, without detecting the miſapplication to the mechaniſm of the vaſcular ſyſtem.—The firſt part of the obſervation informs us ‡, "That a very ſmall "part only of the reſiſtance of the arteries is "removed each time by any ſingle contraction "of the heart;" but on the contrary, I think no truth can be more evident, than that the whole reſiſtance of the arteries is overcome by every ſingle ſyſtole of the left ventricle; for if otherwiſe,

† This was taught by Mr. Elſe, when I attended his Lectures in 1779 and 1780.

‡ Mihles's Tranſlation of Haller's Phyſiology, Vol. I. p. 97.

otherwiſe, the action of the heart muſt neceſſarily be more frequent than the action of the arteries; agreeable to that well known law in mechanics, that what we gain in power, we loſe in time, and *vice verſa:* and as the arteries contract as much during the diaſtole as they were dilated by the preceding ſyſtole of the heart, the motion of the heart and arteries will conſtantly and regularly correſpond to each other. But to ſupport the argument, it is then obſerved, "That as the ſemilunar valves at the origin of "the aorta will admit of various apertures, the "heart acts upon that hydraulic principle, "whereby any force, ever ſo weak, by urging a "fluid through an aperture proportionably "ſmall, ſhall overcome any reſiſtance, or raiſe "any weight ever ſo great." But as the ſemilunar valves have no power of action inherent in themſelves, and as their motion is occaſioned by the influx and reflux of the blood, the momentum of the blood will not be influenced by the opening of the valves, but on the contrary the opening of the valves will depend on the momentum of the blood; for the action of theſe valves is perfectly mechanichal, and they are preſſed

preſſed upon as powerfully by the blood in the artery, as by the blood in the ventricle of the heart: and though the ſemilunar valves will recede further from each other when the impulſe of the blood is great, than when it is languid, that motion will be equal to the degree of velocity with which the blood enters the artery. But, to favour this hypotheſis as much as poſſible, let us ſuppoſe that the opening of the valves depended on ſome power proper to themſelves, by which the dimenſion of the aperture could be increaſed or diminiſhed; even then the influence that this would have on the motion of the arterial blood would not aſſiſt the power of the heart, as is here ſuppoſed, but on the contrary, if a certain quantity of blood paſſes the ſemilunar valves in a given time, that is, if at each ſyſtole of the heart the contents of the left ventricle are impelled into the aorta, the ſmaller the aperture, the greater muſt be the velocity of the blood through that aperture, and conſequently the reſiſtance to the paſſage of the blood more conſiderable. But the principal tendency of this argument will perhaps be beſt explained, by comparing the power of the heart

to

to the preſſure of a column of water, or any other fluid of a given perpendicular, and a certain baſe; then if a ſecond tube of equal dimenſions be united to the bottom, and placed parallel to the firſt that contains the column of water, whoſe perpendicular preſſure repreſents the power of the heart, they will appear like the form of a capital U, or an inverted ſyphon; and ſuppoſe that the preſſure of the water in the ſecond tube repreſents the reſiſtance of the arteries, in this ſituation the gravity of the one will undoubtedly equipoiſe the gravity of the other, and this will be invariably the ſame, whether theſe tubes are united at the bottom by an aperture equal to the whole, or of only one tenth, or even any other inconſiderable proportion of the diameter of the tubes; which aperture, in this inſtance, repreſents the opening of the ſemilunar valves. Then the true reaſon why a feeble contraction of the left ventricle of the heart after fainting, &c. is capable of renewing the circulation, is, becauſe the arteries, during the ceſſation of the motion of the heart, having nearly completed their vacuity, and conſequently their diſtention being diminiſhed, their reſiſtance

will

will be diminiſhed in proportion, and then a leſs powerful impulſe of the heart will be ſufficient to reſtore the motion of the blood; and at the ſame time, as the irritability of the arteries will be diminiſhed, their muſcular action will not be ſo powerfully excited by the ſtimulus of the blood, and their power of re-action as much diminiſhed as the power of the heart, and the juſt proportion between the power of the heart and the reſiſtance of the arteries be equally preſerved. But it is not neceſſary to my preſent purpoſe, that I ſhould point out every error of this kind that might be ſelected from different anatomical writings. I only wiſh to examine ſome of the moſt exceptionable opinions, and anſwer their principal arguments; and the following inſtance ſeems to comprehend every particular that is neceſſary to be advanced on this ſubject: and I ſhould think myſelf guilty of a great omiſſion if I let this obſervation paſs unnoticed, as it has been employed to ſupport an opinion contrary to that which is delivered in the following pages; and ſome readers might conclude that all I have written on the action of the arteries

would ſink under the authority of this important argument.

In this obſervation the circulation of the blood is compared to the operation of a fire engine *, *i. e.* an engine uſed to extinguiſh fire, and the hydraulic principles of the one are ſuppoſed to give a perfect repreſentation of the other. But if we conſider the mechaniſm of a fire engine, and the conſtruction of the vaſcular ſyſtem, it will not be difficult to diſcover the impropriety of this ſimile, and the bad tendency of ſuch deluſive illuſtrations. But before we proceed to examine the general tendency, it will be neceſſary to obſerve, that the arteries are not conical, but perfect cylinders; the neceſſity of which form will be ſhewn in the following ſection:

* Dr. Kirkland has aſſerted, that "If the leathern "tube of a fire engine were made elaſtic, and ſomewhat "conical like the arteries, I doubt not, were its end at "liberty, or incloſed in a ligature, but it would undergo "a ſimilar motion from the paſſage of the water. And "I am perſuaded this inſtrument repreſents the manner "in which the blood is made to circulate through the "body." Medical Surgery, Vol. I. p. 313.

ſection. Firſt, to give a ſhort deſcription of a fire engine, that it may be ſufficiently underſtood for the preſent purpoſe: it is compoſed of two forcing pumps that act alternately; a large air veſſel, in which the air is condenſed by the preſſure of the water; a long cylindrical leathern tube, at the end of which is fixed one made of braſs or copper, of a conical form, by means of which the external orifice of the tube, which is the outlet of the engine, is diminiſhed, and the velocity of the water proportionably increaſed; and thus by the ſucceſſive action of each embolus in the cylinders, the two cylinders alternately diſcharge their contents into that part of the engine that communicates with the air veſſel; and as the re-action of the condenſed air on the ſurface of the water is conſtantly equal to the power of the engine, the lateral preſſure of the water againſt the ſides of the leathern tube will be regularly the ſame, ſo that was the leathern tube ever ſo elaſtic, as the diſtending power acts without intermiſſion, the tube will not dilate and contract, but will remain in a ſtate of diſtention equal to the lateral preſſure of the water. But on the contrary, when

a quantity of blood is diſcharged into the aorta by the contraction of the heart, the ſyſtole of the left ventricle immediately ceaſes, and the arteries that were diſtended by the ingreſs of the blood, have time to contract and regain their former dimenſions; for the contents of the arteries are propelled with different degrees of power at different intervals, being actuated moſt forcibly when the arteries are moſt diſtended, and leaſt ſo when they are moſt contracted. But here it will be neceſſary to obſerve, that the preſſure of the condenſed air does not add to the power of the engine, as has been ſuppoſed by ſome writers †; it only ſuſtains the preſſure of the water; and, whilſt the engine is in motion, conſtantly re-acts with a power equal to its condenſation. But although the operation of

† Dr. Mihles ſuppoſes, "that to the power of the heart "the arteries ſerve as a multiplying ſpring, by their "elaſtic force proportionable to their diſtention; and "drive forward the blood and continuous juices in the "ſame manner as the air by its ſpring throws out a con-"tinued ſtream, with a celerity proportionable to its "compreſſure in the fire engine, or forcing pump." Tranſlation of Haller's Phyſiology, Vol. I. p. 97.

of the fire engine bears very little analogy to the circulation of the blood, the operation of a ſingle forcing pump with a long leathern tube will be found to be ſomewhat ſimilar to the action of the heart and arteries, for when the capacity of the cylinder of the pump is increaſed by the aſcent of the embolus, the water ruſhes in to ſupply the vacuum, ſo does the blood into the evacuated ventricle of the heart; and as the blood is forced into the aorta by the ſyſtole of the ventricle, ſo when the capacity of the cylinder is diminiſhed by the deſcent of the embolus, the water is forced into the leathern tube, and as often as the water is forced into the leathern tube, it will be evidently dilated, and when the acting power ceaſes, the tube will immediately contract by its elaſtic power: and thus by the repeated action of the pump, the leathern tube will alternately dilate and contract in a manner ſomewhat ſimilar to the diaſtole and ſyſtole of the arteries; and if the arteries were nothing more than elaſtic membranes, and perfectly void of muſcular power, they would even then dilate and contract in the ſame manner as the leathern tube, but it is impoſſible that they ſhould be perfectly free from motion, unleſs their reſiſt-

ance was greater than the lateral impulſe of the blood.—As for the operation of any hydraulic engine, that can only be mechanical; but the animal functions are influenced by powers that depend on very different principles: ſo that the moſt accurate deſcription of the one will give but a very imperfect repreſentation of the other. But if what has been ſaid on this ſubject is not ſufficient to convince every impartial reader of the bad tendency of this method of reaſoning, let him conſider how the great Boerhaave was deluded by mechanical opinions; or Freind's Emmenalogia will afford ſome of the moſt ſingular inſtances, where the powers of the animal œconomy have been erroneouſly explained on mechanical principles; and where even the *modus operandi* of certain medicines was ſuppoſed to have been demonſtrated by chemical experiments.

SECT.

SECT. III.

Of the Form of the Arteries, and the Nature of their Diaſtole.

THE principal improvement that modern anatomiſts have made in the doctrine of Arteriology, conſiſts in a clear inveſtigation of the true form of the arteries, which is an object of the firſt importance towards aſcertaining the comparative velocity of the blood through the different branches of the arterial ſyſtem; that is, the proportion that the motion of the blood in one part bears to the motion of the blood in other parts of the *arterial ſyſtem:* for the comparative velocity of the blood will, *cæteris paribus*, depend on the form of the veſſels, the number of ramifications, and the proportion which the ſum of the areas of all the ramifications, at any given diſtance from the heart, bears to the area of the original trunk. But to form a tolerable idea of the motion of the blood, it is neceſſary firſt to be well acquainted with the conſtruction of the arteries, not only *ſepa-*

rately, as diſtinct veſſels, but collectively, and to know how all the arteries united compoſe a perfect ſyſtem of veſſels, whoſe dimenſions, form, reſiſtance, and diſtance from the heart, bear ſuch an equal proportion to each other, that in a ſtate of health, the blood is thereby equally diſtributed to all the different parts of the body; for though the heart ſupplies the arteries with blood, and impels it through their moſt minute ramifications, the proportionate diſtribution depends alone on the action of the arteries, and not on the power of the heart. The general opinion of all anatomical writers relating to the form of the arteries was, that theſe veſſels were parts of *longy* extended cones, whoſe diameters decreaſe as they divide into more numerous branches; and even Haller† expreſsly mentions the conical form of the arteries, and only points out a few inſtances

† Haller, ſpeaking of the pulſation of the arteries, ſays, "The *conical form* of the arteries much contributes to the "producing this phænomenon; for it is for this reaſon, "that the impulſe of the blood againſt the parieties of "the arteries, is (in proportion to the diſtance) ſo much "the greater, as they are the more diſtant from the heart."

Tranſlation

inſtances ‡ where the arteries are cylindrical. But the irregularity with which the blood would move through a ſyſtem of veſſels thus conſtructed, is ſo inconſiſtent with that conſtant ſimplicity that appears in every part of the animal œconomy, that this conſequence is alone ſufficient to prove the fallacy of this opinion.—For inſtance, the velocity of a column of blood propelled through a conical veſſel, would, as it proceeds, increaſe in proportion to the diminution of the area of the veſſel, ſo that § the velocity of the blood would vary in every part of the ſame veſſel; and at every ramification, as the areas of the original veſſel, and the additional branch, taken together, conſiderably exceed the dimenſions of the original trunk (which may be conſidered as a well eſtabliſhed and generally received opinion);

Tranſlation of Haller's Diſſertation on the Motion of the Blood, &c. p. 29.

And the Tranſlator mentions, "That the learned au-
"thor preſented it to the Royal Society at Gottingen,
"Oct. 8, 1754, and it is publiſhed in the fourth volume of the Tranſactions of that learned aſſembly."

‡ Elementa Phyſiologiæ, Tom. I. p. 157.

§ Enfield's Inſtitutes of Natural Philoſophy, p. 85.

opinion); the velocity of the blood, which was before increaſing, would at the ramification be conſiderably diminiſhed, and would continue to be diminiſhed through the ſucceeding parts both of the original veſſel and the ramification; and theſe veſſels being alſo ſuppoſed to be conical, the blood would proceed through their cavities in like manner with increaſing velocity, until it arrived at thoſe parts where theſe veſſels gave out additional branches. Hence appears the neceſſity of what is now well known, that the arterial tubes are perfectly cylindrical, from the origin of the aorta to the ſmalleſt branches; and this being the true form and conſtruction of the arteries, all the irregularities above deſcribed will be avoided, and the blood will move through every veſſel with a perfectly regular velocity, which will only diminiſh at and in proportion to the ſize of the ramification; for as the ſum of the areas of the branches taken together exceeds that of the artery from which they originate, the velocity of the blood will conſequently be leſs in the ſmall than in the large arteries: and though the motion of the blood will be equal in all parts of the ſame veſſel, yet

the

the degree of velocity with which the blood moves through the capillary arteries, compared with the motion of the blood in the aorta, will be in proportion as the ſum of the areas of the capillaries exceeds the area of the aorta at its origination. As for any intermediate eſtimation, that could not be aſcertained with any tolerable accuracy, unleſs we could clearly underſtand what was meant by the different orders of veſſels, which are ſo expreſsly mentioned by ſome authors; as it would be impoſſible to trace a regular gradation from the large to the ſmall veſſels.

THEN the dimenſions and ſtrength of the different branches throughout the whole arterial ſyſtem are ſo juſtly proportioned to each other, that the reſiſtance to the preſſure of the blood is in every part equal. And the quantity of blood that paſſes through any ramification is in proportion to the diameter of the veſſel; and the reſiſtance to the progreſſive motion of the blood is alſo equal in all parts, otherwiſe the diſtribution of the blood would not be equal in proportion to the ſize of the different veſſels; but a greater

greater quantity would paſs through that veſſel where the blood met with leaſt reſiſtance to its motion. This is clearly exemplified in a deſcription that Dr. Hunter has given of a particular ſpecies of aneuryſm, formed by an anaſtomoſis * between the artery and vein, in conſequence

* London Medical Obſervations and Inquiries, Vol. II. p. 390. "There is an anaſtomoſis, or immediate communication between the artery and vein, at the part where the patient had been let blood, in conſequence of the artery being wounded through the vein; ſo that blood paſſes immediately from the trunk of the artery into the trunk of the vein, and ſo back to the heart."

P. 401. "Notwithſtanding the ſize and the force of the pulſation of the brachial artery be much more conſiderable than in the other arm, the artery at the wriſt is much ſmaller, and the pulſation much weaker."

P. 407. "Why is the pulſe at the wriſt ſo much weaker in the diſeaſed arm than in the other? Surely, the reaſon is obvious and clear. If the blood can eaſily eſcape from the trunk of the artery directly into the trunk of the vein, it is natural to think that it will be driven along the extreme branches with leſs force, and in leſs quantity."

P. 408. "Whence is it that the artery is enlarged all the way down the arm?"

P. 409.

quence of paſſing the lancet through the vein into the artery, in the operation of letting blood. The account is too long to be inſerted at full length: I ſhall therefore only abſtract ſuch obſervations as are more immediately applicable to this ſubject. This is a very curious phænomenon, and deſerves particular attention, as it affords a ſtriking inſtance of the effects of diminiſhed reſiſtance in a part of the vaſcular ſyſtem, independent of the influence of diſeaſe; for in caſes of active hæmorrhagy, though there is a greater derivation of blood to the veſſels of the part affected, yet this does not alone depend on diminiſhed reſiſtance, but in ſome degree on the increaſed action of the ruptured arteries.

The

P. 409. "I preſume that the derivation of blood to the arm by the wound of the artery, has been the cauſe of the dilatation of that veſſel; and that, in the living body, an artery will as certainly become larger, when the reſiſtance to the blood is taken off; as it will become ſmaller when it is compreſſed, or as it will ſhrink and become a ſolid cord, when the blood is not allowed to paſs through it at all."

The proper action and only power of the arteries is a power of contraction, which is counteracted by the ſyſtole of the left ventricle of the heart, the blood ſerving as a reſiſting medium, by which means theſe two powers are made to counteract each other; ſo that when a quantity of blood is impelled into the origin of the aorta by the ſyſtole of the left ventricle of the heart, as the reſiſtance of the origin of the aorta is inferior to the power that would be neceſſary to move the whole contents of the arterial ſyſtem with the ſame velocity that the blood is ſent from the heart, conſequently the origin of the aorta will give way to the lateral preſſure of the blood, and will firſt dilated, and this dilatation will proceed with rapidity to the extremity of all the arterial branches, and, by one progreſſive impulſe, diſtend the cavities not only of the larger arteries, but of every minute ramification: for as the re-action of the origin of the aorta is greater than the reſiſtance of the inferior branches; the anterior column of blood, which is propelled with equal power to that with which the aorta is diſtended, will dilate the whole arterial ſyſtem until a perfect equilibrium

is

is reſtored; and when the ſyſtole of the left ventricle of the heart is compleated, the origin of the aorta, which was firſt dilated, will firſt begin to contract; which contraction, by means of the ſucceſſive action of the circular muſcular fibres, proceeds to the extremities of the arteries before the returning ſyſtole of the heart.—So that the diaſtole of the arteries, and the ſyſtole of the left ventricle are compleated in the firſt inſtance, and the ſyſtole of the arteries, and the diaſtole of the left ventricle of the heart begin and end with each other.

It is this progreſſive dilatation and contraction that occaſions what is called the pulſation * in arteries; and though both the dilatation and contraction begin at the origin of the aorta, and end

* Haller's Diſſertation, p. 32. "Modern phyſicians ſay, that the pulſe is produced by a wave of blood going out of the heart with more ſwiftneſs than that which preceded, and had loſt its force by the reſiſtance of the ſmall veſſels; and that the reſiſtance which this wave makes againſt that which it ſucceeds, is the cauſe that its direct courſe is impeded, and that a part of its force is exerted laterally againſt the parieties of the veſſels, and elevates them."

end at the extremity of the branches, yet as fluids preſs equally in all directions, the contents of the whole arterial ſyſtem will conſequently be propelled with a degree of power equal to that with which the origin of the aorta is diſtended, and the momentum of the blood in the extreme ramifications will be immediately affected by the impulſe of the blood entering the aorta from the heart. So that although both the dilatation and contraction of the arteries is progreſſive, the impulſe of the heart will be immediately perceptible in the diſtant parts, or near the circumference of the arterial ſyſtem; that is, in every part where the pulſation of the arteries is evident to the ſenſes.

I MIGHT next endeavour to eſtimate the power of the heart, and the degree of velocity with which the blood moves forward: and if ſuch a diſcovery would conſiderably improve our knowledge of the animal œconomy, I ſhould ſuppoſe that the ſolution of this queſtion would not be attended with the difficulty that ſome have imagined; for though Borelli ſuppoſed that the power of the heart was equal to 180,000 pounds weight,

weight, and Dr. Keill's calculation reduced the force of the left ventricle to eight ounces, ſtill theſe extravagant calculations will not render the taſk more difficult, as they both founded their arguments on equally falſe and erroneous principles. The experiments of Dr. Hales are very ingenious, perfectly ſimple, and well calculated for the intention; and, if repeated with accuracy, would nearly prove what was the power of the heart and arteries in ſuch animals as were the ſubjects of the experiments. But I do not ſuppoſe that this ſingle fact would much improve our knowledge of this ſubject; for though we could eſtimate the power of the heart by numbers or weight, it does not follow that we ſhould have a more complete idea of the effects and extent of that power, unleſs we could aſcertain with equal accuracy the power and reſiſtance of every part whoſe motion depends on the power of the heart: for though by the power of the heart the blood is not only propelled through the arteries, but is tranſmitted into the veins, and its motion continued through the whole venal ſyſtem to the right ſide of the heart, and even into the cavity of the right

auricle, yet it would be very difficult, if not impoſſible, to tell what degree of power in the heart would be neceſſary to produce theſe effects, and give motion to the blood: though it is well known, that the velocity with which the blood will flow from a punctured vein is very conſiderable, and that the motion of the blood firſt depends on the power of the left ventricle of the heart.

SECT.

SECTION IV.

Of the Syſtole of the Arteries, and the Motion of the Blood during the Diaſtole of the Heart.

PREVIOUS to deſcribing the ſyſtole of the arteries, it will be neceſſary to prove that they do dilate and contract, though it is a fact ſo ſelf-evident, that it appears rather ſingular that it ſhould ever be doubted; for as by the ſyſtole of the heart the blood is firſt put in motion, if the blood continues to move through the arteries when the ſyſtole of the left ventricle ceaſes, that motion cannot depend on the power of the heart, but muſt be occaſioned by ſome power inherent in the arteries only, by which they contract themſelves, and, by a conſtant action, preſs forward the blood through their cavities. For if the arteries had no power of diminiſhing their cavities, it would be impoſſible that the blood ſhould be diſcharged from a wounded artery during the diaſtole of

the left ventricle of the heart.—Then the manner in which the blood is diſcharged from a wounded artery will not only prove that the arteries do dilate and contract, but will with equal certainty explain the manner of their action: for inſtance, when an artery is wounded, the ſtream of blood does not ſtop when the ſyſtole of the left ventricle ceaſes, but continues with diminiſhing velocity, until the artery is again diſtended by a freſh ſupply of blood from the heart; for the velocity of the blood from the orifice of a wounded artery is greateſt at that inſtant when the whole arterial ſyſtem is completely diſtended, and that is, when the action of the heart is exerted with ſufficient power to diſcharge the whole contents of the left ventricle into the aorta. From which it is evident, that the re-action of the arteries is in proportion to the degree of diſtention; and when the whole arterial ſyſtem is in the full diaſtole, the re-action of the arteries, and the power of the heart which dilated them, are perfectly equal to each other. And for theſe reaſons, the velocity of the current of blood from a wounded artery will always be equal to

the action of the artery: and, as was before obſerved, the action will be in proportion to the degree of diſtention; but as the contraction of the artery continues, but does not complete the vacuity of the veſſel before the returning ſyſtole of the heart, the ſtream of blood from a wounded artery never ceaſes. But if the arteries were perfectly void of muſcular power, and at the ſame time not poſſeſſed of the leaſt degree of elaſticity, and conſequently abſolutely incapable of either being diſtended or contracted, the whole contents of the arterial ſyſtem would neceſſarily remain in a quieſcent ſtate during the diaſtole of the left ventricle of the heart, and the blood would ceaſe to move in a ſound artery, or flow from one that was divided: therefore, as this ſimple fact is uniformly the ſame in every inſtance, that the ſtream of blood from a wounded artery continues whilſt the left ventricle of the heart is in its diaſtole, it not only proves that the arteries do contract, but the power of their contraction is thereby demonſtrated.

To aſcertain the different degrees of the power of the arteries, Dr. Hales* made an experiment, by fixing a perpendicular glaſs tube into one of the carotid arteries of a horſe, in which the blood aſcended the higheſt when the heart contracted, and deſcended during the ſyſtole of the artery; ſo that the weight of the column of blood in the tube was in every inſtance equal to the contractile power of the arteries.

Although Haller† has, contrary to the opinion of Boerhaave‡, poſitively aſſerted that the coronary arteries are never ſo ſituated as to admit of the poſſibility of being ſhut up by the ſemilunar valves, yet I ſuppoſe few modern anatomiſts who have attentively examined the conſtruction of the parts in a variety of inſtances, will deny that ſuch inſtances do ſometimes exiſt in

* See Statical Eſſays, by Dr. Hales.

† Haller's Diſſertation, p. 29.

‡ Boerhaave's Lectures, Vol. II. p. 153.

in nature; and where the apertures of the coronary arteries are ſo ſituated, that when the ſemilunar valves recede to admit the blood from the left ventricle, they fall back againſt the ſides of the aorta, and by covering the entrance into the coronary arteries, prevent all communication between theſe veſſels during the ſyſtole of the ventricle. But when the diaſtole of the ventricle takes place, and the ſemilunar valves approach each other, to prevent the return of the blood from the aorta; then the blood being preſſed by the contraction of the whole arterial ſyſtem ‖, will immediately paſs into the open mouths of the coronary arteries.

But if the arteries did not contract; when the ſemilunar valves were thus ſituated, the coronary arteries could not be ſupplied with blood, which, under theſe circumſtances, evidently proves the neceſſity of the ſyſtole of the

 arteries;

‖ Whytt, p. 24.—During the diaſtole of the heart, all its coronary veſſels, which were in a great meaſure emptied by the preceding ſyſtole, are filled with blood violently puſhed into them by the contraction of the aorta.

arteries; and as no other difference but the ſituation of the apertures is obſerved to attend this variety, but that the form, the ſize, and the ſtrength of the coronary arteries are perfectly ſimilar in both inſtances, there is every reaſon to conclude, that whether the blood is impelled by the ſyſtole of the heart or the ſyſtole of the arteries, the circulation through the veſſels of the heart is equally perfect.

The next conſideration is, by what means this contraction of the arteries is performed; whether by an inanimate, or what has generally been termed an automatic elaſticity, or by muſcular power: and the complete vacuity that takes place in the arteries after death, or † when the communication with the heart is intercepted, is perhaps the only evidence that nature will afford on this important queſtion. If the muſcular coat of the arteries had never been diſcovered or deſcribed, their ſyſtole might then have been attributed to the former of theſe properties; but the very exiſtence of muſcular fibres,

† Boerhaave's Lectures, Vol. II. p. 23.

fibres, when we attend to their direction, and the nature of muſcular action, is a powerful argument in ſupport of a contrary opinion: and as the muſcular coat of the arteries may be expoſed to view without any great degree of anatomical ſagacity, I ſhould ſuppoſe that no one will venture to deny its exiſtence.

Nor will the arguments that Dr. Whytt‖ has advanced to prove what he terms the oſcillatory motion of the ſmall veſſels, more ſatisfactorily explain the action of the arteries, which cannot be conſidered as oſcillatory; for if words have any preciſe ſignification, this is to ſuppoſe that at leaſt the ſmall arteries poſſeſs in themſelves not only a power of contraction, but alſo a power of expanſion: and if this could be demonſtrated, we might then conclude, that the action of the arteries depended alone on a principle of elaſticity; but as the only power of the arteries is a power of contraction, their diaſtole muſt depend on the power of the heart, and not on any inherent property of expanſion;

‖ Whytt's Works, p. 226. ſect. 2.

panſion; for if the ſyſtole of the arteries depended upon elaſticity, as the final contraction of the whole arterial ſyſtem is ſo complete, that all the contained blood is tranſmitted into the veins, when no freſh ſupply of blood * can come from the heart, theſe veſſels would neceſſarily remain in the ſame contracted ſtate; becauſe when there was no power to counteract this tendency, the arteries would be contracted to whatever degree their power of contraction was capable of exerting its influence; and as nothing but a complete contraction could evacuate the arteries, as they are found perfectly empty after death †, it is certain that they have been completely contracted, otherwiſe their vacuity

* See Haller's Diſſertation, p. 252. or Medical Muſeum, p. 260. a better tranſlation of Haller's original Paper.

† Haller's Diſſertation, p. 56.—This phænomenon, perhaps, is the cauſe that deceived the ancients, who imagined that the arteries contained only air. And p. 58.—It is always the caſe after death, that the arteries empty themſelves by degrees, until at laſt they become abſolutely white, without the leaſt remains of blood.

vacuity would not be perfect, but ſome blood would remain in their cavities.

And as the arteries are not found in a contracted ſtate, it is evident that their power of contraction does not depend on elaſticity; for when the blood is all evacuated, the action of the arteries ceaſes, which undoubtedly proves to demonſtration that their contraction is effected by muſcular power, which is excited into action by the ſtimulus of the blood.

I shall not on this occaſion (agreeable to the example of Dr. Whytt*) attempt, *à priori*, to ſhew the aptitude of the blood to act as a ſtimulus, or to enquire into the nature of the animal fibre, to prove the exiſtence of ſuch a property as is generally underſtood by what is termed the irritability of the arteries; theſe will appear moſt indiſputably evident by their operations and effects: for if the arteries never ceaſe to contract ſo long as the blood remains in their cavities, and as ſoon as the blood is impelled

* See Whytt's Works, p. 228, 229.

pelled into the veins, their action ceaſes, and they become perfectly paſſive, relaxed, and flaccid; this may certainly be conſidered as a clear demonſtration that the contents of the arteries occaſion their contraction, by exciting the action of their muſcular fibres, in the ſame manner as the blood in the ventricles occaſions the contraction of the heart: and thus the ſyſtole of the heart and the ſyſtole of the arteries depend on principles perfectly analogous to each other; for the heart and arteries are both muſcular, and in both inſtances their muſcles conſtantly act in the direction of their fibres when the blood is preſent, and immediately ceaſe to act when the blood is evacuated.—But as the arteries have not time to complete their vacuity before the returning ſyſtole of the heart, the remaining quantity of blood will continue to excite the action of their muſcular fibres, which will prevent a ceſſation of their contraction ſimilar to the diaſtole of the heart; and in this circumſtance, the motion of the heart and the motion of the arteries differ from each other, for the diaſtole of the arteries does not, like the diaſtole of the heart, depend on relaxation

tion from the want of excitement; but is occaſioned by a quantity of blood impelled from the heart overcoming their reſiſtance, and forcibly diſtending their cavities; and as the power by which the arteries contract themſelves will be found conſiſtent with the nature of muſcular motion, when compared with the powers and properties of other muſcles, it is evident that the proper action of the arteries is perfectly muſcular.

These arguments will alſo receive additional evidence from the phænomena of ſome diſeaſes; for if the powers of nature admit of the poſſibility that one part only of the arterial ſyſtem, and perhaps ſometimes only a ſingle ramification, or even only a part of a veſſel is ſo affected, that the natural action is morbidly increaſed, (as in caſes of local inflammation, when the action of the veſſels of the part affected, and conſequently the momentum of the contained fluids is ſupernaturally increaſed, and when at the ſame time the action of the heart, and every other part of the vaſcular ſyſtem does not exceed the healthy ſtandard) the

the reſult muſt be, that that increaſed action cannot be occaſioned by the power of the heart, but muſt depend on ſome power then only exiſting in that degree in thoſe arteries that are in a ſtate of inflammation, and conſequently that not only the heart itſelf, but every part of the whole arterial ſyſtem, does poſſeſs the ſame property that influences their action.

What this property is, would probably be difficult to determine; at leaſt, if we look back ſo far, and it is to be conſidered as an original property of animated matter. But if a certain limitation is attended to, the laws that govern the animal functions may be made ſufficiently evident, although the nature of the cauſe ſtill remains unintelligible. For the power is made evident by its effects; and to be certain of the exiſtence of the fact, is ſufficient for the preſent occaſion.—The queſtion then is, whether, in caſes of inflammation, the action of the arteries exceed the healthy ſtandard, and whether inflammation is ever limited? and both theſe facts are ſo well known, and ſo univerſally admitted, that it muſt appear rather ſuperfluous to point out

out a ſingle inſtance; but as the ſtate of the arteries is particularly evident in an inflammatory ſtate of the tunica conjunctiva, this inſtance is well worthy of obſervation, and more ſo, as in all probability the hypotheſis that ſuppoſes that an error loci was the cauſe of inflammation, firſt originated from this phænomenon; and alſo as Dr. Whytt* has made uſe of ſimilar arguments nearly on the ſame occaſion: and though he has committed ſome very conſiderable errors, yet what he has written on this ſubject has met with very extenſive, if not general approbation. When treating of the motion of the blood-veſſels, he ſays, "The "diaſtole† of the arteries, like the diaſtole of the "heart, is owing to the blood being puſhed into "their cavities with a conſiderable force;" but does not explain from whence that force proceeds: and then he adds, "That beſides the "alternate diaſtole and ſyſtole of the larger "arteries, which, in a great meaſure, depend "upon the projectile force of the heart, and the "elaſticity of their coats, there is a vibrating or "oſcillatory

* Whytt's Works, p. 53. † Ibid. p, 213—226.

" oſcillatory motion in the inferior orders of " veſſels, to which the direct force of the heart " does ſcarcely reach, and where elaſticity is not " concerned." And afterwards we find a whole ſection ‡ employed in attempting to prove by mathematical demonſtrations, that the power of the heart is not ſufficient to continue the motion of the blood through the ſmall veſſels.

NOTHING can be more evident, than that the diaſtole of the heart and the diaſtole of the arteries are both occaſioned by the influx of blood into their cavities; but, as has been before obſerved, they are very different from each other: for as the arteries are never empty, and as their contraction depends on the preſence of the blood, they are conſtantly in a contracting ſtate, and require a power ſuperior to that by which they do contract, to overcome their reſiſtance; but as the cavities of the heart are nearly, if not completely emptied at every ſyſtole, the cauſe of action being removed, the heart after

‡ Whytt's Works, p. 230.

after every ſyſtole becomes *inactive*, *relaxed*, and *flaccid*, and conſequently gives *very little* reſiſtance to the influx of the blood, which is alſo much facilitated by the mechaniſm of the heart itſelf. The buſineſs of the auricles is firſt to receive the venal blood, the right from the two cavas, the left from the pulmonary vein; and as much leſs power is neceſſary in the right auricle to fill the right ventricle, than for the right ventricle to force it through the lungs—and in the left auricle to fill the left ventricle, than for the left ventricle to force the blood through the whole body, it is reaſonable to ſuppoſe (what is evident in the conſtruction) that the muſcular power of the auricles is much inferior to the muſcular power of the ventricles; and conſequently that the auricles will give much leſs reſiſtance to the influx of the blood, than if it was firſt received into the ventricles. And though it would be difficult to aſcertain what degree of power would be neceſſary to overcome this reſiſtance, it cannot be ſuppoſed to amount to what may with propriety be called conſiderable force, when compared to the force with which the blood enters the aorta; for if

the motion of the blood alone depends on the power of the heart, the momentum muſt undoubtedly be diminiſhed by friction and other cauſes, before it arrives at the right ſide of the heart. But if the inferior order of veſſels (to which we are told the direct force of the heart does ſcarcely reach) poſſeſs an additional power of propelling the blood, it may then be poſſible that the momentum of the blood in the vena cava may exceed the momentum of the blood in the aorta.

But if this oſcillatory motion is the effect of muſcular motion, and the muſcular fibres of theſe veſſels are excited into action by the ſtimulus of the circulating fluids, they muſt either be in a ſtate of conſtant contraction, or muſt empty themſelves at intervals before they can become diſtended; and being once evacuated, the freſh ſupply of blood, which can only come from the larger arteries, muſt neceſſarily be forced forward by the power of the heart and larger arteries: and as Dr. Whytt has not attempted even to ſuppoſe by what means the dilatation of the ſmall veſſels is performed,

we may ſafely conclude, that the ſmall veſſels do not poſſeſs any inherent power of dilating themſelves, more than the larger arteries; and that, agreeable to the mechaniſm of the vaſcular ſyſtem, there is but one method by which both the large and ſmall arteries can properly be dilated, and that is, the vis a tergo that originates in the power of the left ventricle of the heart.

And as this inferior order of ſanguiferous veſſels to which the direct force of the heart does ſcarcely reach, have never yet been either diſcovered or deſcribed; this doctrine of oſcillatory motion (where it is ſaid that even elaſticity is not concerned) is not only contrary to every known law of the animal œconomy, but there is no part of the whole vaſcular ſyſtem where the cauſe of its motion is not demonſtratively evident, without the neceſſity of any ſuch unintelligible hypotheſis.

SECT. V.

Of the Effects of Bleeding.

FROM what has been ſaid in the preceding Sections, it appears that the whole arterial ſyſtem is in an active and contracting ſtate, ſo long as the blood remains therein, and conſequently the capacity of the arteries muſt always be in proportion to the quantity of blood which they contain; and though they will admit of different degrees of diſtention, without doubt there is a certain degree, beyond which if they are dilated, they loſe their power of action, of which we have frequent inſtances in caſes of aneuryſm.

IN order therefore to preſerve health, or to cure diſeaſe, it is neceſſary that an exact equilibrium ſhould be preſerved or reſtored between the different acting powers of the animal machine; and with this intention, when the vaſcular ſyſtem is too much diſtended, either by too great

great a quantity of blood, or the action of the arteries is increaſed by inflammation, it is then directed to diminiſh the quantity of blood by phlebotomy, and there is no doubt but the whole quantity of blood will be diminiſhed in proportion to the quantity that is taken away; and as the quantity of blood may be reduced to any degree by bleeding, this will conſequently prove the moſt expeditious method of correcting plethora: but as frequent bleeding has a powerful tendency to promote a diſpoſition to plethora, this * ſtate of the conſtitution will be more effectually corrected by a proper management of diet, exerciſe, and ſleep; and the lancet ſhould never be uſed except there is reaſon to apprehend that ſome immediate danger will occur in conſequence of the fulneſs of the veſſels, or that the plethora is connected with an inflammatory tendency; and it is the concurrence of theſe two circumſtances that eſtabliſhes the neceſſity of phlebotomy—for † inflammation

 alone,

* Cullen's Practice of Phyſic, Vol. II. p. 167—170.

† Dr. Smith ſays, "It may happen, that even in inflammatory diſeaſes, eſpecially when they have been of

ſome

alone, when not attended with a tenſion of the arteries, no more authorizes the uſe of the lancet than plethora without inflammation, as the inflammation may be corrected by internal medicines with leſs diſadvantage to the patient's conſtitution. But here it will be neceſſary to obſerve, that there are frequent inſtances of local inflammation connected with local plethora, where the ſyſtem is not generally affected, and which equally require the uſe of the lancet; and as inflammation attended with plethora is not only ſometimes perfectly local, but in moſt inſtances there is one diſtinct part that is more immediately affected, and where the diſeaſe firſt originated, it has been thought more efficacious to make the evacuation from thoſe veſſels that were moſt contiguous to, and were ſuppoſed to be more intimately connected with that part which was the ſeat of the diſeaſe, with an intention

ſome days continuance, blood-letting may prove injurious; for if the pulſe, inſtead of being full, high, and tenſe, ſhould be low, weak, and ſoft, it will be expedient to excite rather than lower the vis vitæ; and cordials in this caſe will be the beſt remedies to reſolve the inflammation."—See Phyſiological Eſſays, p. 126.

tion of inviting the blood to or from different parts of the body, as the circumſtances of particular caſes might require.

But as our knowledge of anatomy has improved, theſe opinions have been leſs attended to; and the different methods that are now retained in practice are bleeding in the arm, opening the temporal artery, cupping, leeches, and ſometimes bleeding in the foot, in caſes of ſuppreſſion of the menſes.

Bleeding in the arm is moſt in uſe; and I am of opinion, that it will not be difficult to prove that this method will anſwer every intention, and prove preferable on every occaſion where an evacuation of blood is neceſſary; and though in ſome caſes, taking away a ſufficient quantity of blood by any one of the above methods may be productive of evident good effects, yet as the object of bleeding is to diminiſh the action of the vaſcular ſyſtem, and the momentum of the blood—and as this does not alone depend upon the quantity that is evacuated, but alſo in a conſiderable degree upon

the expedition with which the evacuation is made, and on the part from which the blood is taken, that method will without doubt be thought preferable by which the power of the valcular ſyſtem is moſt diminiſhed, with the leaſt loſs of blood. Dr. Cullen * obſerves, "That when blood-letting is neceſſary, it is "more effectual, as the blood is more ſuddenly "drawn off:" and Huxham † not only mentions the advantage of making a large orifice, but ſays, that in ſome inſtances he has ſeen ſurpriſing good effects from bleeding in both arms at once. But to make the truth of theſe obſervations appear more evident, it will be neceſſary to examine how the motion of the blood is immediately affected by the diſcharge from a punctured veſſel.

If then, as has been ſhewn by Haller, a ligature was made on the ſuperior and inferior cava ‡, the motion of the heart would immediately

* Cullen's Practice of Phyſic, Vol. I. p. 115.

† Huxham on Fevers, p. 178—184.

‡ Haller's Diſſertation, p. 153.

diately ceaſe, and the arteries would be no longer ſupplied with blood; and as the arteries would continue to contract ſo long as the blood remained in their cavities, the arteries would immediately empty themſelves, and all the blood would be accumulated in the venal ſyſtem. This evidently proves, that the power with which the veins contract is inferior to the power of the arteries; on which account the venal ſyſtem becomes a more fit reſervoir to receive the blood from the arteries, and to ſupply the heart.

THEN as the power of the heart will, *cæteris paribus*, depend on the quantity of blood that comes from the cava, that power will be diminiſhed in proportion to the diminution of the ſupply of blood to the right ſide of the heart: and when in caſes of inflammation the action of the arteries is increaſed, they will conſequently contain leſs blood, and a greater quantity will be accumulated in the veins; and therefore the moſt effectual method of reducing the momentum of the circulation will be to diminiſh the quantity of blood in the cava, and as the greateſt

greateſt part of the blood that is diſtributed to the arm may be prevented returning to the cava by a ligature, and evacuated by an orifice in any of the veins in the bend of the arm as faſt as thoſe veins are ſupplied by the arteries; this will not only be found to be the moſt convenient part for the operation, but as any given quantity of blood may be diſcharged from a vein in the arm in leſs time than from any other part of the body, this will alſo prove the moſt effectual method of diminiſhing the accumulation of blood in the cava, and the power with which the blood enters the right auricle of the heart, and conſequently of diminiſhing the power of the heart, and the momentum of the blood, in every part of the vaſcular ſyſtem.

By way of illuſtration, let us ſuppoſe that by a large orifice in the arm a pound of blood is taken away in one minute, as the blood which is evacuated would have paſſed forward to the heart if the vein had not been opened, the quantity of blood that is returned to the heart during the operation will be leſs in nearly equal proportion to the quantity diſcharged: then as it

it ſeldom happens that there is any conſiderable degree of general inflammation without ſome degree of fever, ſuppoſe the number of pulſations of the heart amounted to eighty in a minute—and let it alſo be ſuppoſed that two ounces of blood paſſed the heart at every pulſation—according to this propoſition, ten pounds of blood would paſs the heart in one minute, the time propoſed for the expeditious compleating of the operation; and thus as a pound of blood is taken away from a vein during the time that ten pounds of blood is paſſing the heart, either a leſs quantity of blood muſt paſs the heart at every pulſation during the operation, or the pulſations be leſs frequently performed; and Haller † informs us, that the frequency of the pulſations is not immediately influenced by bleeding: but as this is an experiment

† Haller ſays, "In a continual fever, many of which, and very troubleſome ones, I laboured under at Gottingen, I was blooded; before the operation, my pulſe had 122 pulſations in a minute; it retained the ſame velocity during the operation, and after it was finiſhed."—Diſſertation, p. 94.

ment that may be eaſily repeated, thoſe who have any doubts may ſatisfy themſelves by their own obſervations. Then if the pulſations continue to be performed in the ſame time, a leſs quantity of blood will be received into the different cavities of the heart during their diaſtole, and conſequently a leſs quantity will be impelled into the aorta at every ſyſtole of the left ventricle, and the arteries will be leſs powerfully diſtended. But if under the ſame circumſtances, as before ſtated, the ſame quantity of blood was by a ſmall orifice evacuated in four minutes, as the quantity of blood that would paſs the heart in four minutes would be four times the quantity that would paſs the heart in one minute, the power of the heart would without doubt be diminiſhed in much leſs proportion; and although theſe arguments will not admit of demonſtrative proof in favour of the concluſion that is drawn from them, it will be right to conſider, that an expeditious evacuation of blood will more frequently produce fainting than a ſlow one.

THEN if by taking away any given quantity of blood by a large orifice, the power of the heart and arteries will be as much reduced as if double the quantity was evacuated with leſs expedition, the firſt method muſt appear preferable to the latter, becauſe it will not ſo much reduce the ſtrength of the ſubject; and that reduction of ſtrength which is occaſioned by a great loſs of blood is not very eaſily recovered, but is frequently productive of very diſagreeable, if not fatal conſequences. The queſtion then is, in caſes where bleeding is neceſſary, to aſcertain with accuracy how much, and only how much, ought to be taken away—and in ſome caſes this will be a very difficult point to determine. To take away rather too much blood will be erring on the ſafe ſide; and there are but few inſtances where the loſs of three or four ounces of blood more than the nature and circumſtances of the diſeaſe may abſolutely require, will prove very prejudicial to the conſtitution: but if, inſtead of a few ounces, pounds of blood are unneceſſarily taken away, this becomes an object of great importance; and ſo large an evacuation of the vital fluids ought not

to

to be ventured upon without very attentive and ſerious conſideration.

I HOPE it will now appear evident, that by a large orifice in one of the veins in the bend of the arm, or, according to Huxham's method, in both arms at the ſame time, the impetus of the circulation may be reduced to any degree, with the leaſt diſadvantage to the animal œconomy, and ſo as beſt to promote the intention of correcting every kind of morbid affection where bleeding is particularly indicated. It remains, that we examine the nature of topical bleeding; and I ſhall firſt conſider the effects of opening the temporal artery. The diſeaſes that are ſuppoſed to require this operation depend on affections of the brain; ſuch as in caſes of apoplexy, in concuſſions and compreſſions of the brain from external injury, &c.—And even in ſuch inſtances, if the intention is to prevent or diminiſh the increaſed action of the veſſels of the brain, bleeding in the arm will be more advantageous than opening the temporal artery. It has been before ſhewn, that bleeding in the arm will moſt expeditiouſly

diminiſh

diminiſh the power of the heart; and as this is effected by diminiſhing the ſupply of blood to the heart, conſequently the diſtribution of blood to all parts of the arterial ſyſtem will be diminiſhed in proportion, and a leſs quantity of blood will be ſent to the brain. But in addition to theſe effects, (which are common to all parts of the body) the plethoric ſtate of the ſinuſes of the dura mater will be moſt effectually corrected by diminiſhing the quantity of blood in the cava; for as there is a perfectly free communication between the ſinuſes of the dura mater and the ſuperior cava, their degree of plenitude will be nearly equal when the body is in a horizontal poſition, but in an erect poſition the blood will preſs downward by the power of gravity, and conſequently the preſſure on the brain will be thereby diminiſhed; and for this reaſon it is proper, in all plethoric affections of the brain, to keep the body in an erect poſition. It is well known that the ſinuſes of the dura mater, in a natural ſtate, contain a conſiderable quantity of blood—if, then, the capacity of the cranium is a little diminiſhed by a depreſſion, which is ſo occult that it cannot be diſcovered

with

with ſufficient certainty to authorize the application of the trepan, and the brain itſelf is no otherways affected but by the compreſſion, there cannot be a more ſpeedy and effectual method of giving room to the brain, than by diminiſhing the quantity of blood in the ſinuſes of the dura mater, by an evacuation from the arm; and if the brain ſhould alſo be affected by inflammation, the neceſſity of bleeding will be increaſed.

But to return to the effects of arteriotomy.—When the temporal artery is opened, the reſiſtance to the progreſs of the blood through the external carotid artery becomes leſs conſiderable, and the velocity of the blood in the external carotid artery will be increaſed in proportion as the reſiſtance is diminiſhed; ſo that a larger quantity of blood will paſs through this branch during the evacuation, than before the temporal artery was divided—but nearly the ſame quantity of blood will continue to paſs through the internal branch of the carotid artery to the brain: for the quantity that paſſes the internal carotid artery will not be diminiſhed in proportion

proportion to the increaſed quantity that paſſes the external branch, but in the proportion that the increaſed quantity bears to the diſtribution of blood to every part of the arterial ſyſtem; for as the preſſure of the blood in the carotid artery at the origination of the internal and external branch is the ſame in all directions, the quantity that enters each veſſel will be in proportion to the area of their tranſverſe ſections, and the degree of reſiſtance. And as the reſiſtance to the blood in the internal branch of the carotid artery that leads to the brain is neither increaſed nor diminiſhed by opening the temporal artery, the quantity of blood that is ſent to the brain will not be immediately influenced by the evacuation: but as a greater quantity will paſs through the external branch, where the natural reſiſtance is diminiſhed by the diviſion of the temporal artery, an increaſed proportion of blood will enter the carotid artery; and conſequently, during the time that the blood continues to flow from the temporal artery, the diſtribution of the blood to the carotid artery will be increaſed, and proportionably diminiſhed with reſpect to every other part of the arterial

ſyſtem, and the different veſſels will adapt themſelves to the different proportionate quantities; and every artery will become contracted in proportion to the diminiſhed diſtribution of blood, except the carotid artery, which will at leaſt preſerve the ſame dimenſions as before the operation, if not become more dilated, as this veſſel will receive an additional quantity of blood whilſt the evacuation from the temporal artery is continued: ſo that when the intended quantity of blood is evacuated, and a bandage is applied to ſtop the orifice in the veſſel, the blood will not only ceaſe to flow out at the orifice, but the temporal artery will be completely obliterated by the preſſure of the compreſs, and conſequently a greater proportion of blood will paſs the internal carotid to the brain for ſo long a time after the operation, until the whole arterial ſyſtem ſhall have recovered a ſtate of equal action, with the loſs of a branch of the external carotid artery.—For as the carotid artery was before the operation accuſtomed to tranſmit a proper ſupply of blood both for the external and internal branches, this veſſel will ſtill be in a ſtate to receive its

uſual

uſual quantity of blood, whilſt every other artery will, during the operation, have been accuſtomed to receive a leſs quantity; and as the blood cannot paſs the temporal artery after the operation, every other ramification of the carotid artery will receive an additional ſupply of blood: and thus the internal carotid will convey a larger quantity of blood to the brain, immediately after the temporal artery is cloſed, than what paſſed to the brain before the operation took place; and for theſe reaſons the only good effects of opening the temporal artery in morbid affections of the brain will be to relieve the plethora, by diminiſhing the quantity of the whole maſs of blood, but by a method the moſt diſadvantageous to that part which is the ſeat of the diſeaſe. The ſame reaſoning may be uſed to explain the effects of the loſs of blood that is occaſioned by the operation of ſcalping; in this inſtance the hæmorrhagy is principally arterial, and, during the diſcharge, the effect will be perfectly ſimilar to what is occaſioned by opening the temporal artery; and the obſtruction that takes place when the hæmorrhagy ceaſes, will be productive of ſimilar effects, and in a de-

gree equal to the extent of the operation.—Then if the operation is very extenſive, and a great number of veſſels are divided, the quantity of blood that will paſs through the external branch of the carotid artery, after the operation is completed, and the extremities of thoſe veſſels are become obſtructed, will be conſiderably leſs than what paſſed when the parts were in a ſound ſtate, and conſequently, as has been ſhewn before, immediately after the operation the quantity of blood that is ſent to the brain will be proportionably increaſed; therefore, if the power of the heart and arteries has not been ſufficiently reduced by the loſs of blood in conſequence of the operation, the neceſſity of taking a proper quantity from the arm by a large orifice, muſt appear too evident to require any further arguments.

What has been ſaid of the effects of opening arteries, will be found in a great meaſure applicable to the ſtate of the arterial ſyſtem in caſes of hæmorrhagy; but in addition to theſe circumſtances in caſes of hæmorrhagy, there is generally an increaſed action of the ruptured veſſels,

veſſels, depending upon a phlogiſtic affection. This increaſed action frequently precedes the rupture, and is indicated by a heat and ſenſe of fulneſs in the part affected, which continue increaſing until the veſſels can no longer reſiſt, and conſequently give way to the preſſure of the contained fluids. Then when one veſſel or more, as it may happen, become ruptured, the blood will meet with leſs reſiſtance in thoſe veſſels, than in the other parts of the arterial ſyſtem; and an increaſed proportion of blood will paſs the ruptured veſſels, and every other artery will contract in proportion to the diminution of the quantity of blood that it receives. It will be alſo evident, that the longer the hæmorrhagy continues, the greater will be the degree of this contraction; and if the diſeaſe is left to nature, the diſcharge will continue until the preſſure of the blood in the arteries becomes inferior to the reſiſtance of the ruptured veſſels. The queſtion, as propoſed by Dr. Heberden, will naturally follow*: "If it be intended by "this practice (*i. e.* taking away blood from

* Medical Tranſactions, Vol. II. p. 529.

" the arm or foot) to weaken the power of the " heart, and to give the lips or ends of the " broken veſſel a chance of collapſing, or of " being plugged up by means of a more lan- " guid circulation; would not all this be as " likely to happen after the patient had been " equally weakened from the original rupture, " and in the mean time he might ſtand a chance " of its ſtopping ſpontaneouſly, before he was " reduced to that degree of weakneſs?" It is a well known fact, that if fainting comes on, the action of the heart, and conſequently the motion of the blood, is for a ſhort time ſuſpended; this is proved by every day's experience: and I ſuppoſe few will deny, that an expeditious evacuation of blood by a large orifice in the arm will be more likely to produce fainting, than the tedious dropping of the ſame quantity of blood from the noſe. If then by bleeding in the arm the action of the heart and the motion of the blood may for a time be completely ſuſpended, it is reaſonable to conclude, that though the effect may not amount to fainting, ſtill (as has been before ſhewn) the momentum of the blood may be reduced to

any

any degree by an evacuation from the arm, and with the leaſt loſs of blood in point of quantity. But the object in this inſtance is not only to diminiſh the momentum of the arterial blood, but to preſerve or reſtore the equilibrium of the arterial ſyſtem: and as the diſcharge of blood from the ruptured veſſels will have a contrary tendency, it is evident that the plethoric ſtate of theſe veſſels will be more effectually corrected by a diſcharge of any given quantity of blood from the arm *, than by a much more conſiderable quantity from the ruptured veſſels; and if, according to the opinion of Dr. Hunter and Mr. Hewſon †, the diſcharge is ſtopped by the blood coagulating in the lacerated apertures, this coagulation will not ſo readily take place whilſt the blood is flowing through the parts, as if the neceſſary evacuation was made from any other veſſel.

Cupping, and bleeding with leeches, are more generally practiſed at this preſent time than any other kind of topical bleeding. But after all the arguments I have heard urged on

* Cullen's Practice of Phyſic, Vol. II. p. 174.

† Hewſon's Experimental Enquiry, p. 68.

this ſubject, and after the moſt attentive obſervation, I muſt acknowledge that I have never met with a ſingle inſtance where the ſuperior efficacy of either method was deciſively evident. I ſhall therefore proceed to deſcribe how theſe two different methods may be ſuppoſed to operate, in the ſame manner, and on ſimilar principles, on which I have attempted to explain every other part of this ſubject.

Though cupping is generally uſed with an intention of more immediately evacuating the veſſels of certain parts, when we conſider in what manner the arteries and veins are diſtributed to the different parts of the body, it will be impoſſible to explain how cupping on the ſhoulder, or on any part of the cheſt, ſhould more effectually correct the plethoric ſtate of the lungs than bleeding in the arm. Indeed Huxham * writes as if he wiſhed to recommend cupping

* "Drawing of blood by cupping on the ſhoulders, &c. may be done with ſafety, and frequently gives exceeding great relief in diſorders of the breaſt, as well as of the head, though the reaſons may not be very obvious and aſſignable."

cupping in pulmonic diſorders; but his reaſons for preferring this method to phlebotomy do not appear to depend on a ſuppoſition that the blood that is evacuated by cupping comes more immediately from the part affected, but from an opinion that the loſs of blood by cupping will not debilitate ſo much as if the ſame quantity was taken from the arm. There is no doubt but his opinion was founded on what he had repeatedly obſerved in practice, and is an additional proof of what has been before obſerved, that the immediate effects of an evacuation of a certain quantity of blood will depend in a conſiderable degree on the expedition with which the evacuation is made: and for this very reaſon, bleeding in the arm will always prove preferable when a loſs of blood is neceſſary. The veſſels that are divided by the ſcarificator

aſſignable."—Huxham on Fevers, p. 197.—And p. 212. "When I was diffident as to bleeding, I ordered ſcarifications and cupping ſometimes with ſucceſs; though in one or two caſes, the effuſion from the ſcarification was vaſtly profuſe, and could not be totally reſtrained till the patient expired."

ficator are ſo very ſmall, that it would be impoſſible to trace them by the knife from the larger branches; but it is proved by injections, that they are ramifications of the larger arteries and veins, that convey the blood to and from the ſurface of the body: but then theſe arteries bring the blood from the heart, and the veins return it to the heart again; ſo that the evacuation by cupping, in whatever part it is performed, will only correct the plethoric ſtate of the lungs or brain, in proportion to the diminution of the quantity of the whole maſs of blood. In this operation the arteries and veins are both cut without diſtinction, but the arteries will diſcharge the greateſt quantity, for the evacuation from the veins will chiefly depend upon the influence of the exhauſted cupping-glaſs; and thus the courſe of the blood being intercepted, the quantity that is taken away is prevented returning by the veins to the heart—ſo that the effects of cupping at the time of the operation would be perfectly ſimilar to the effects of bleeding in the arm, if the blood was diſcharged with the ſame expedition; but the evacuation is ſo ſlow, that the impetus of the circulation cannot be

be greatly influenced by the immediate effects of the operation, in any other degree than what may be eſtimated by the quantity taken away: and thus, in proportion to the quantity, cupping will as effectually diminiſh the plethoric ſtate of the whole vaſcular ſyſtem, as any other method by which the ſame evacuation is made in the ſame ſpace of time.—But it does not appear reaſonable to ſuppoſe that cupping will prove particularly efficacious as a topical application.

The uſe of leeches may not improperly be conſidered as an inferior kind of cupping; and as in this inſtance the evacuation is alſo made from the cutaneous veſſels, the effects will be perfectly ſimilar in proportion to the quantity of blood that is taken away. But it will be equally difficult to explain how plethoric affections of the brain can be relieved by the application of leeches to the temples, as by drawing off blood by cupping on the ſhoulders; for the veſſels of theſe parts have no immediate connection with the veſſels of the brain, except at the origin of the external and internal branches of the carotid artery, and if this can occaſion any particular

particular effect on the veſſels of the brain, in all probability it will be ſimilar to the effects of opening the temporal artery. But if the quantity that is taken away by leeches is ſufficient to diminiſh the tenſion of the whole vaſcular ſyſtem, then the manner in which this operation ſucceeds in correcting the plethoric ſtate of certain parts may be eaſily accounted for, without having recourſe to the inexplicable doctrine of topical bleeding; and if the quantity is ſo inconſiderable that no ſuch effect can reaſonably be expected, in ſuch inſtances it is moſt probable that the effects which are attributed to the evacuation depend on ſome other cauſe: for when a number of remedies are uſed at the ſame time, it is difficult to aſcertain the powers of any one of them ſeparately. I have been more careful and ſcrupulous in forming theſe opinions, as I know this is a method of practice which has a great number of advocates; and that I might not be deprived of the aſſiſtance of a remedy that is ſo generally approved, I have not only frequently directed the uſe of leeches, but have repeatedly attended to the whole proceſs with the utmoſt diligence and circumſpection,

and

and I muſt acknowledge that I never met with a ſingle circumſtance that appeared deciſively favourable to the general opinion. But as this operation may at leaſt be conſidered as perfectly innocent, in oppoſition to what has been advanced it may be urged, that if it does no good, it will do no harm; and indeed this at firſt view may appear plauſible on ſome trifling occaſions, where the diſeaſe is cured more by the effects that are produced on the mind than on the body. But if in caſes (ſuppoſe of apoplexy) where a part or the whole of the vaſcular ſyſtem is in that ſtate, that, without proper evacuations, the powers of the animal machine cannot be long preſerved; if, in ſuch a caſe, an evacuation by means of leeches is depended on, and is inadequate to the purpoſe, and if at the ſame time a certain quantity taken from the arm would prove ſufficient, the poſſibility of which I think appears evident from the preceding arguments, then the different conſequences of the different deciſions of the point in queſtion will only be life or death.

F I N I S.

ERRATA.

P. 1. line 8, for *was a ſubject*, read *were ſubject*.
P. 59. line 7, for *propoſition*, read *ſuppoſition*.

BOOKS in MEDICINE, SURGERY, &c.

Printed for J. JOHNSON, No. 72, St. Paul's Church-Yard.

1 AIKIN on the Uſe and various Preparations of Lead, with Remarks on Goulard, 2d edit. 1s 6d
2 ——— Thoughts on Hoſpitals, 1s 6d
3 ——— Tranſlation of Beaumé's Manual of Chemiſtry, with Notes, 3s 6d ſewed, 4s bound, 2d edit.
4 ——— Edition of Dr. Lewis's Materia Medica, with Additions, 4to. 1l 4s in boards
5 ——— Biographical Memoirs of Medicine in Great Britain, from the Revival of Literature to the Time of Harvey. 4s. ſewed
6 Albinus's Tables of the Skeleton and Muſcles of the Human Body, with fine plates, large folio, 3l 3s half-bound
7 Alanſon on Amputation, and the After-Treatment, with an Account of the Amputation above the Ancle, with a Flap, 2d edit. greatly enlarged, 6s bound
8 Alexander's experimental Enquiry concerning the Cauſes which have generally been ſaid to produce putrid Diſeaſes, 4s 6d bound
9 Black's Obſervations on the Small-Pox and Inoculation, ſewed, 3s 6d
10 ——— Hiſtorical Sketch of Medicine and Surgery, from their Origin to the preſent Time; and of the principal Authors, Diſcoveries, Improvements, Imperfections and Errors, 6s bound
11 Buckner's eaſy Method to make Deaf Perſons to Hear 1s 6d
12 Bell on Ulcers, 8vo. 6s. in boards
13 —— Syſtem of Surgery, 5 vol. 1l. 10s. in boards
14 Cullen's Firſt Lines of the Practice of Phyſic, 4 vol. 1l 4s in boards
15 ——— Noſologia Methodica, 2 vol. 12s boards
16 Curry on the Nature of Fevers; on the Cauſes of their becoming ſo frequently Mortal; and on the Means to prevent it, 1s 6d
17 Cheſelden's Anatomy, 7s bound
18 Dawſon's Caſes in the Acute Rheumatiſm and Gout, with the Method of Treatment, 6s bound
19 ——— Account of a ſafe and efficacious Medicine in Sore Eyes and Eye-lids, 1s.
20 Elſe on the Hydrocele, and other works; with ſome new Caſes of the Hydrocele, and a compariſon of the different

ferent Methods of treating it by Caustic and Seton. By G. Vaux, 2s 6d sewed

21 Elliot's Physiological Observations, 1s 6d

22 —— Medical Pocket-Book, 2s sewed

23 ——— Account of the Medicinal Virtues of the principal Mineral Waters in Great Britain and Ireland, and on the Continent: with the Method of impregnating Water with fixed Air, invented by Dr. Priestley, and improved by others, 3s sewed

24 ——— Elements of the Branches of Natural Philosophy connected with Medicine, viz. Chemistry, Optics, Electricity and Physiology. With Bergman's Tables of Elective Attractions, 5s sewed

25 Fothergill's Works, with Memoirs of his Life, by Dr. Elliot, 6s sewed

26 Fordyce's (Geo.) Practice of Physic, 5s sewed

27 ——— Elements of Agriculture, a Syllabus of his Chemical Lectures, 2s 6d sewed

28 Falconer's Observations and Experiments on the Poison of Copper, 2s sewed

29 Hunter's (Dr. W.) 34 Plates of the Gravid Uterus, with Explanations in Latin and English. The few Copies of this superb Work that remained unsold at the Author's Death, may be had at 3l. 13s 6d, which is 2l. 12s 6d under the Original Price

30 ——— Medical Commentaries, 4to. 6s in boards

31 ——— Two Introductory Lectures, 4to. 6s in boards

32 Hunter's (John) Natural History of Anatomy, and Diseases of the Human Teeth, with 16 Copper-plates, 4to. 1l. 1s bound

33 Hawson's Experimental Enquiries, on the Blood, 3s.

34 Hoffman's Practice of Physic, with a great Number of Cases, translated by Dr. W. Lewis, and revised by Dr. Duncan, 2 vol. 8vo. 12s in boards

35 Henry's Experiments on Magnesia, 2s 6d

36 Hippocrates upon Air, Water, and Situation; upon Epidemical Diseases and Prognostics, translated by Clifton, 5s bound

37 Lavoisiere's Essays: Containing a History of Discoveries relating to Air, &c. with Original Experiments, translated from the French by T. Henry, F. R. S. with Notes, 7s. bound

38 Lewis's Materia Medica, a new Edit. with Additions, by J. Aikin, M. D. price 1l. 4s in boards

39 Laws relating to Physicians, Surgeons, and Apothecaries, digested by T. Cunningham, Esq. 2s 6d sewed

40 Monro's

40 Monro's (Alex. jun.) Obſervations on the Structure and Functions of the Nervous Syſtem, with 55 Copper-plate Tables, folio, 2l 12s 6d in boards

41 Monro on Mineral Waters, 2 vol. 12s

42 Motherby's New Medical Dictionary, or General Repoſitory of Phyſic: Containing an Explanation of the Terms, and an Account of the Diſcoveries and Improvements in Anatomy, Phyſiology, Phyſic, Surgery, Materia Medica, Pharmacy, &c. with Copper-plates, folio, 2l 2s bound

43 Morgagni on the Seat and Cauſes of Diſeaſes, tranſlated by Alexander, 3 vol. 4to. 1l 11s 6d in boards

44 Obſervations on the Character and Conduct of a Phyſician, in Twenty Letters, 8vo. 2s 6d ſewed

45 Prieſtley's Hiſtory of Electricity, 4to. 4th Edit. 1l 1s bound

46 ——— Introduction to the Study of Electricity, 2s 6d

47 ——— Experiments and Obſervations on different kinds of Air, 6 vol. 8vo. 1l 16s in boards

48 Percival's Obſervations and Experiments on the Poiſon of Lead, 2s

49 Park's Account of a new Method of treating Diſeaſes of the Joints of the Knee and Elbow. In a Letter to Mr. Pott, 1s 6d

50 Smith's Formulæ Medicamentorum, or Compendium of the Practice of Phyſic, 5s in boards

51 Sims's Obſervations on Epidemic Diſorders, with Remarks on Nervous and Malignant Fevers, 2d edit. 5s bound

52 —— Diſcourſe on the beſt Method of proſecuting Medical Enquiries, read before the Medical Society, 2d edit. 2s

53 Scheele's Experiments on Air and Fire, with an Introduction by Bergman: tranſlated by Dr. Forſter, with Notes by Mr. Kirwan, and a Letter from Dr. Prieſtley, 3s 6d ſewed

54 Theobald's Diſpenſatory, compiled for the Uſe of the Army, 3s bound

55 Wilſon's Medical Reſearches, being an Enquiry into the Nature and Origin of Hyſterics in the Female Conſtitution, and into the Diſtinction between that Diſeaſe and Hypocondriac or Nervous Diſorders, 4s boards

56 Zimmerman on Experience in Phyſic, 2 vol. 8vo. 12s bound